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SOIL STABILIZATION FOR PAVEMENT CONSTRUCTION USING CHEMICAL STABILIZERS

Engineering

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ABSTRACT

Soil is the base on which all the structures stand and transfer the load. Soil has to be stable to bear all the types of load transferred on it. Soil has different classification; one class of classification called black cotton soil has the least tendency to bear the heavy loads imposed on it. The construction of structures such as highway is difficult and challenging too. Soil has the property bear all kinds of loads, but they are restricted to certain limits. Suppose for a black cotton soil California Bearing Ratio (CBR) value is least to a value between 1.4 to 1.8. But for the soil to fit as sub grade the Code of practice for Roads suggests California Bearing Ratio value should be higher than 5. Soil should exhibit maximum Dry Density (MDD) with lower Optimum Moisture Content (OMC). The moisture content is soil not only reduces the dry density of soil but it has the same impact on unconfined compressive strength, Atterberg's limits especially Shrinkage limit and California Bearing Ratio.

KEYWORDS

Black Cotton Soil, Teerasil, Zycobond, UCS, CBR, OMC, MDD

I. INTRODUCTION

Soil is one of the major natural resources, like air and water. It is the topmost layer of the earth's crust and is a mixture of fine powdered rocks, organic matter, liquids, myriad organisms and other minerals. It acts as an interface between hydrosphere, lithosphere, earth's atmosphere and biosphere. The proportion of the key ingredients determines the type of soil. But, factors such as vegetation, climatic conditions, human activities for e.g. grazing, farming, gardening etc… also influence soil formation.

The major types of soils found in India are:
I. Laterite Soil
II. Mountain Soils
III. Black Soil
IV. Red soil
V. Alluvial Soil
VI. Desert Soil
VII. Saline and Alkaline Soil

A. Analysis of Engineering Properties of Black Cotton Soil

● Owing to moisture variations, these clays exhibit considerable variation of shear strength and compressibility and swelling, which causes differential movement,

● resulting in severe damages to foundations, buildings, roads, embankments, retaining structures, canal lining, and more.

● The problems associated with these soils can be controlled by the techniques given below.

● By changing the property of the soil by chemical injection (lime stabilization, cement stabilization, etc.).

● By isolating the soil using geo membranes so that there will be no moisture change.

● Soil reinforcement technique to counter-act swelling pressures.

II. Materials Used And Their Properties

A. Black Cotton Soil

● Black cotton soil (BC soil) is a highly clayey soil. The black colour in Black cotton soil (BC soil) is due to the presence of titanium oxide in small concentration.

● The Black cotton soil (BC soil) has a high percentage of clay, which is predominantly montmorillonite in structure and black or blackish grey in colour.

● Expansive soils are the soils which expand when the moisture content of the soils is increased.

● The clay mineral montmorillonite is mainly responsible for expansive characteristics of the soil.

● The structures on Black cotton soil (BC soil) bases develop undulations at the road surface due to loss of strength of the sub-grade through softening during monsoon.

● The physical properties of Black cotton soil (BC soil) vary from place to place 40 % to 60 % of the Black cotton soil (BC soil) has a size less than 0.001 mm.

B. Terrasil

Terrasil is a water soluble, UV and heat stable, reactive soil modifier to reduce swelling. Spray of Terrasil water solution waterproofs compacted soil surface upto 10 mm depth. It restricts swelling to < 5% for expansive soils.

Sl No	Property	Value
1	Chemical Composition:-	Hydroxyalkyl-alkoxy-alkylisylil-compounds 65-70% Benzyl Alcohol 25-27% Ethylene Glycol 3-5%
2	Form	Liquid
3	Color	Pale Yellow
4	Flash Point	80ºC
5	Density	1.01g/ml
6	Freezing point	5 ºC
7	Solubility	Miscible with water pH Value 10
8	Viscosity	100-500 CPS

D. Cement

Ordinary Portland cement is been used to assure the binding of chemical stabilizer with soil particles and also to improve Unconfined Compressive Strength of soil. Physical Properties

Sl No	Property	Value
1	Form	Liquid
2	Viscosity	100-500 CPS
3	Colour	White
4	Odour	Mild
5	Flash point	Not Flammable
6	Density	1.01-1.02 g/ml
7	Boiling point	100 ºC
8	Solubility	Dispersible in water pH Value 6.5-8

C. Zycobond

Zycobond is a UV stable cross linkable soil modifier. It is anano sized acrylic copolymer dispersion in water. It compliments conventional stabilization methods by imparting water resistance and flexible bonding to the soil.

Sl No	Property	Value
1	Specific Gravity	3.12
2	Normal Consistency	29%
3	Initial Setting Time	65 minutes
4	Final Setting Time	275 minutes
5	Fineness	330 kg/m²
6	Soundness	2.5mm

Physical And Chemical Properties.

III Scope And Objective

The Following Main Scope And Objectives Have Been Identified For The Present Work:

1. To determine the optimum dosage of Teraasil by conducting Free Swell Index Test.
2. To fix the optimum dosage of Cement by conducting Unconfined Compression Strength Test for a given dosage of Zycobond.
3. To determine the optimum dosage of Zycobond by conducting CBR test.
4. To achieve a CBR value of more than 7% as specified NHAI for Subgrade use.

IV Expected Outcome

1. Increased CBR value of > 7%.
2. Increase in Unconfined Compression strength.
3. Liquid Limit < 25 % , Plasticity Index < 6 & Shrinkage Limit < 17%.

V Properties Of Black Cotton Soil

Sl. No	Property	Value
1	Specific Gravity	2.4
2	Liquid Limit	68.65 %
3	Plastic Limit	48.59 %
4	Plasticity Index.	20.06 %
5	Shrinkage limit.	47.65
6	OMC.	28.41 %
7	MDD.	1.482kN/m³
8	CBR	1.67
9	UCS.	1.40 kN/m²
10	Free Swell Index	44.44 %

VI RESULTS AND DISCUSSION

● Free Swell Index Test

Free swell Index Test has been Conducted as per IS2720 for both natural soil as well for soil mixed with Terrasil. The Terrasil dosage has been varied from 0.1-1.2 kg/m³. The Free Swell Index of Natural Black Cotton Soil is 47.37 %. We have conducted FSI tests by varying the Terrasil dosage from 0.1 kg/m³ to 1.2 kg/m³. The FSI values keep decreasing until 1.0 kg/m³ Terrasil dosage. The FSI at this dosage is 20. Hence we con 1.0 kg/m³of Soil as optimum dosage. The Terrasil dosage has been varied from 0.1 kg/m³ to The Free Swell Index of Natural Black Cotton Soil is 47.37 %. We have conducted FSI tests by varying the Terrasil dosage from 0.1 kg/m³ to 1.2 kg/m³. The FSI values keep decreasing until 1.0 kg/m³ Terrasil dosage. The FSI at this dosage is 20.

● Unconfined Compression Strength Test

With the fixed dosage of Terrasil as 1kg/m³ and Cement as 3% by weight of soil and varying the dosage of Zycobond from 0.1kg/m³ to 0.6kg/m³, Consistency Limits Test is carried out. We have observed good improvement of soil properties in terms of Consistency Limits. Plasticity Index value of natural soil is 20.06 and at 0.6 kg/m³ of Zycobond the value reduced to 3.08. Similarly Shrinkage Limit also decreased from 47.67% to 13.78%.

● Modified Proctor Test

With the fixed dosage of Terrasil as 1kg/m³ and Cement as 3% by weight of soil and varying the dosage of Zycobond from 0.1 kg/m³ to 0.6 kg/m³, Modified Proctor Test is carried out. And we have observed that from 0.1 kg/m³to 0.4 kg/m³, Dry density has increased from 1.52g/cc to 1.63g/cc and Optimum Moisture Content has decreased from 27.19% to 16.77%. But at 0.6 kg/m³of Zycobond Dry Density has decreased to 1.52g/cc and OMC become 21.26%.

●CBR Test

The CBR has increased from 1.67 to 10.22 which is 7 times the initial value. The maximum CBR of 10.42% may observed at 0.6 kg/m³ zycobond dosage. But at 0.4kg/m³ CBR is 10.22% , there is no such significant variation and we observed a decrement in MDD of soil, Hencewe fix the Maximum dosage of Zycobond to 0.4kg/m³ of soil. As per Indian Standards The plasticity Index should be less than 10 and shrinkage limit should be less than 17. Also Unconfined Compression Strength of soil observed 5.59kN/m² at 3% Cement by weight of Soil. Hence our experimental results satisfy the requirements as per NHAI Publication 2013.

VII CONCLUSION

1. From Particle Size Distribution Curve, Uniformity Coefficient (Cu)is 1.58 and Coefficient of Curvature (Cc) is 1. Hence we concluded that the Soil is Clayey Soil.
2. The Free Swell Index value is 47.36% for natural soil and at 1kg/m³ of Terrasil it is 20% which has reduced by 58 %.
3. The initial Unconfined Compression strength 1.40kN/m² and the Unconfined.

Compression strength achieved at 3% cement by weight is 5.59 kN/m². Hence we observed about 400% increment in Unconfined Strength of Soil.

4. In Consistency limit Test Results, the Plasticity Index has reduced from 20.06 to 3.02, nearly 600% reduction and shrinkage limit has reduced from 47.63% to 13.78%, nearly 350% reduction, which make Soil to fit for Subgrade use.
5. The CBR value has increased from 1.67 % to 10.22 %, which is approximately 700% more than the CBR of Natural Soil. It satisfies minimum requirement for soil as a sub grade as per NHAI.
6. From above results on Soil treated with Terrasil, Zycobond and Cement, the maximum dosage can be decided as follow.

i. Terrasil 1 kg/m³ of Soil
ii. Zycobond 0.4 kg/m³of Soil
iii. Cement 3 % by weight of Soil

VIII Future Scope

1. Durability Test: For knowing the aspect of life span of treated subgrade soil, Durability has to be performed.
2. Fatigue Test: To study the behaviour of Stabilized soil under repeated load condition.

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